Development of an Arctic Low Frequency Ambient Noise Model

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LONG-TERM GOAL

Our long-term goal is to develop a low frequency ambient noise model capable of predicting extreme (loud/quiet) noise events in Arctic ice-covered waters due to the presence or absence of storms.

OBJECTIVES

We wish to determine the internal stress of the ice canopy covering the Arctic ocean due to convergent atmospheric forcing and relate this to energy dissipation rate due to ridge building, the major source of ambient noise in the frequency regime under consideration.

APPROACH

We plan to use the Navy's Polar Ice Prediction System (PIPS) to determine the ice stress and energy dissipation rate over the ice-covered Arctic Ocean on a daily basis. The energy dissipation rate due to intense ice fracturing (ridge building) caused by migrating polar storms will be related to the source level of the ambient noise based on noise data acquired by ice-mounted drifting buoys. The source level density (per unit area) will then be propagated to randomly placed distant receivers using the modified Ambient Noise Directional Estimating System (ANDES) to calculate the noise field. High resolution SAR imagery will provide a quantitative representation of the number and spatial density of newly created pressure ridges which we assume are directly related to the increase in ambient noise due to storm forcing.

WORK COMPLETED

PIPS data are being saved daily starting with December 1997, including fields of ice divergence, along with daily FNMOC atmospheric forcing fields from NOGAPS. Under contract to this grant, Bill Hibler wrote an energy dissipation code which has been forwarded to Ruth Preller at NRL-SSC to be included in the operational PIPS runstream.

RGPS data from the Canadian RADARSAT satellite for November 1996, obtained from the JPL web site, have been analyzed by our student (LT Speckhahn). The divergent/convergent ice deformation fields at 3-day intervals was shown to be highly correlated with the passage of migrating lows.

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We have acquired a 3-month ambient noise time series measured at the SHEBA site (Nov 1997-Feb 1998) and the RGPS data for this time period.

Along with Bert Semtner (NPS) and Ruth Preller (NRL-SSC), I co-organized and hosted an ONR-sponsored workshop to design a plan to create a new version of PIPS (to be called PIPS 3.0).

RESULTS

Month-long, three-day sequences of RADARSAT RGPS ice divergence fields were shown to be related to alternate cycling of atmospheric forcing. Synoptic scale low pressure systems cause divergence and lead formation and subsequent growth of a thin ice cover. The return of the atmospheric high pressure cell induces convergence and subsequent crushing of the thin ice as new pressure ridges are formed. This is especially noted in coastal regions of the Canadian Basin when offshore winds were followed by onshore winds several days later.

The PIPS ice divergence field provided a fair indication of ice deformation in coastal areas by underestimated the magnitude of ice deformation in the central basin in regions of thick, nearly continuous ice cover. This is mainly a feature of the coarse (20 km) spatial resolution of the current PIPS model.

The PIPS 3.0 workshop outlined the community development effort and process to create a new ice forecasting model based on the fully-coupled, high resolution (9 km x 9 km) model of Semtner, Zhang and Maslowski at NPS. An appropriate parameterization of the ice rheology appears to be the major area of uncertainty.

IMPACT/APPLICATIONS

Our model output in designed to assist submarines when operating beneath the Arctic ice cover. Submarine tactics related to detection/counter detection are strongly dependent on the magnitude of the noise field.

We have also demonstrated that a high resolution, directional ambient noise model can be used inversely to locate regions of high ridging intensity which has operational significance for submarines. In addition, the new PIPS 3.0 model, with its high resolution energy dissipation and divergence fields, should be able to identify regions of open water/thin ice and ridge formation. Knowledge of the areal extent of such features should provide more accurate estimations of the atmosphere-ice-ocean heat exchange as well as direct operational support to submarine, ice camps, etc.

TRANSITIONS

None at the moment, but great potential exists for creation on an operational forecast for ice-covered waters.

RELATED PROJECTS

Our need for an output field energy dissipation rate from PIPS has been addressed by Bill Hibler (Dartmouth /NPS) and Ruth Preller (NRL-SSC). Once incorporated, they will make PIPS runs for us covering the SHEBA drift area for winter 1997-8.

The JPL RADARSAT team (Ron Kwok) will attempt to provide a better estimate of the ridged ice produced as a result of our being a new “customer” for RGPS products.

PUBLICATIONS

Speckhahn, M. M., Identification of acoustically active Arctic pressure ridges through the use of RADARSAT geophysical processor system (RGPS) sea ice products, Master’s thesis, Naval Postgraduate School, Monterey, June 1998.